

REVIEW ARTICLE

Gluten-free bread from ingredients and nutrition point of view: A Mini-Review

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ABSTRACT

Consistent gluten consumption leads to one of the most prevalent immune-mediated disorders i.e. celiac disease (CD). Gluten derived from wheat, rye and barley exhibit antigenic properties that may promote immune reactions in some receptive individuals. Hence, a life-long gluten-free diet (GFD) is being recommended as the best therapeutic treatment. Nevertheless, several research fonts have revealed that gluten-free (GF) products play a vital role in the diet, but bakery goods, especially gluten-free bread (GFB) indicate technological challenges and demonstrate sensory, nutritional and quality imbalances. To overcome these issues, numerous investigations such as raw materials or processing technologies are being carried out. To the best of our knowledge, to date no permanent solution has been evolved for replacing the gluten completely, though the combination of certain ingredients, additives and technologies are providing promising results, keeping the door open for further improvements. This review aims to collect recent information on approaches, improvements and still existing gaps in GF bread making.

Keywords: Gluten; Nutrition; Ingredient; Disorder; Diet

INTRODUCTION

The demand of gluten-free products (GFP) is gradually increasing for 2 main reasons i.e. increased number of consumers having celiac disease (CD), Non-Celiac Gluten sensitivity (NCGS) or wheat allergy (WA) switching to GFD, and because of the public belief that GFP is healthier (Ortiz, 2017;Hartmann, 2018). This trend has a stronger effect on the increase of GF consumer goods since the number of people participating in this trend is growing faster than the number of those who are following the diet due to the proven medical reasons. It has been forecasted that global sales have increased by 10.4% per annum between 2015 and 2020 (Topper, 2018).

Gluten, a prolamin protein is mostly found in wheat (gliadin), barley (hordein), rye (secalin) and in their cross-bred grains along with oats (Capriles and Arêas, 2014). Therefore, the only effective treatment for CD, NCGS or WA is to adapt GFD lifelong and avoid gluten-containing cereals and cross-contaminated products (Ortiz, 2017).

In Europe, 20 mg/kg of gluten (EU 828/2014) is considered as GF; however, the average gluten intake in

a Western diet is around 5-20 g/day. It can be noted that the labeling of cross-contamination is not mandatory and clearly defined; therefore, adherence to the gluten-free diet implies consumption of the products having gluten-free statements and/or claim, defined by the respective nations worldwide (Biesiekierski, 2017).

A consumer survey study revealed that the consumers are satisfied with the quality of GF bland, sweets, and pasta, but still, a significant improvement is needed in GFB and cakes to meet the consumers' expectations (Roman, 2019;Ozola, 2014 and Potter, 2014). However, due to the lack of gluten, the GF alternatives are inferior to the gluten-containing products concerning quality, functional and sensory properties. Besides, when it comes to GFP, they differ from the normal diet in every aspect including price. For example, the texture of the GF bread crumb is of poor quality and becomes dry and stale soon. During raw material (water, yeast, GF flour, starches, additives) mixing and baking the dough is not able to retain the air and carbon dioxide from yeast fermentation or forms irregular cells, which results in low volume, quality and texture defects (Capriles, 2014). The colour of the crumb is

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pale, there is a strong aftertaste, the viscosity and rheology characteristics of the bread dough do not meet those of wheat flour dough, and the price of gluten-free products and ingredients are generally high (Arendt, 2002; Pacynski, 2002; Morreale, 2018; Fry, 2018 and Missbach, 2015). The lack of gluten end in a liquid batter instead of dough, which results in bread with a crumbling texture, poor colour and post-baking quality defects (Hager, 2012).

From a nutritional point of view GFP– which is often based on rice - have lower protein content and are deficient in lysine. The glycaemic index of different rice breads was also reported to be high ranging from 87 to 93. The carbohydrate and fat content of GFB is high while as the protein content is low, causing imbalanced condition (Haupt-Jorgensen, 2018). The folate, iron and dietary fibre content of GFP were also found to be at lower level versus their gluten-containing counterparts (Alvarez-Jubete, 2009; Hager, 2012). In this review, we aim to provide a conspectus on raw materials such as starches, pseudocereals, hydrocolloids and protein supplements which are studied to improve the quality and nutritional gaps of GFP by definite procedures. (Vici, 2016; Nardo, 2019)

GLUTEN-FREE BREAD PRODUCTS: INGREDIENTS AND NUTRITIONAL ASPECTS

Starches

Retaining the air in the bread crumbs, extending the shelf life and improving the mouthfeel is still challenging in the case of GF bread. However, significant achievements can be obtained with complex mixtures of starches, pseudocereals, protein extracts, hydrocolloids and fibres followed by various technologies i.e. fermentation, enzymes, aeration (Capriles, 2014; Roman, 2019). Currently available products on the market are still not compatible with the gluten-containing counterparts neither in taste nor in texture (Melini, 2019).

The most commonly used gluten-free flours and/or starches in the industry for experimentation purposes are maize and rice, due to cost-effective and hypoallergenic nature, blind taste, and white colour but has some technical limitations due to its poor performance with functional proteins (Mancebo, 2015; Hager, 2012). Therefore, rice flour is mixed with different starches such as corn, tapioca, potato, cassava, sorghum, millet or GF wheat starch for better results (Mancebo, 2015; Kim, 2015; Kang, 2015). These starches show high variability in morphology, gelatinization behaviour, and viscosity yielding resulting major impact on specific volume, hardness, elasticity, and chewiness of bread crumbs (Khoury, 2018; Ziobro, 2012;

Horstmann, 2016). The addition of 20-30% potato starch to rice flour improved the viscosity parameters, uniform air cells, colour, and delayed starch retrogradation and overall sensory acceptability (Kim, 2015). Cassava starch might help to keep the air bubbles inside the dough due to its elastic and high viscosity properties, which develops better crumb characteristics (Onyango, 2012).

Increased level of rapidly digestible starches (RDS) obtained from corn and/or rice in GFB leads to high GI and consequently faster increase of blood glucose and insulin levels (Haupt-Jorgensen, 2018; Lamacchia, 2014). It adds to the disadvantages since the CD has been associated with type 1 Diabetes mellitus (Haupt-Jorgensen, 2018). To overcome this imbalance, usage of the slowly digestible starches (SDS) and resistant starches (RS) was studied. The partial replacement of corn starch with corn and tapioca RS showed an increase in storage stability, elastic texture, soft crumb characteristics, and total dietary fibre content (Korus, 2009). This strategy was beneficial since it proved to be a better way of replacing wheat flour. Even though starch from wheat flour guarantees better viscosity and texture, the usage of tapioca RS and corn had an improved effect on the nutritional value of GF bread (Ogungbenle, 2003).

PSEUDOCEREALS

Among pseudocereals, mainly buckwheat, amaranth, quinoa and teff are in the focus of researches. These grains and flours are a great source of fibres, minerals (calcium, magnesium, iron, zinc, potassium, and copper), polyphenol compounds, and vitamins (riboflavin, niacin, thiamine, pyridoxine, and ascorbic acid) (Collar, 2014; Nascimento, 2014; Gallardo, 2006). The protein concentrates of amaranth and buckwheat are able to lower the serum and hepatic cholesterol as well as triglycerides levels (Escudero, 2006; Tomotake, 2006). A study conducted by Kim et al. (2006) showed some health benefits of amaranth such as hyperglycaemia as it was able to decrease the serum glucose level and increase serum insulin levels in diabetic rats (Kim, 2006).

The usage of pseudocereals also adds value to the nutrition level, significantly softer crumb and higher loaf volume (Alvarez-Jubete, 2010; Wronkowska, 2010 and Wronkowska, 2008). The rice flour-based experiments resulted in good rheology with up to 40-50% buckwheat flour (Wronkowska, 2013; Torbica, 2010). According to Lemos et al. (2012), the preferred amount of amaranth flour is 10% while the addition of 10% of quinoa flour improved bread volume by 7.4% and enhanced the appearance without compromising the taste (Lemos, 2012; Föste, 2014).

Pseudocereals are recommended as an alternative to traditional ingredients for bakery products to lower the GI (Berti, 2004). In contrast, pasta made from 100% teff flour was characterized with the lower in-vitro GI level compared to the white wheat bread (Giuberti, 2016). A study conducted by Wolter et al. (2013) reported that GFB made from 100% buckwheat, quinoa, sorghum and teff were classified as high in-vitro GI food (Wolter, 2013). Based on the data available, pseudocereals can significantly improve the vitamins, minerals, fibre and protein levels, but not always the GI level.

Despite the nutritional and technological benefit of those grains, the usage is limited due to their strong effect on taste, aroma, colour and relatively high cost. High dosage of buckwheat, teff, and quinoa or amaranth flour in bread formulation presents inadequate sensory attributes such as dark-coloured crumb, thick, dark and dry crust, strong smell, taste and flavour (Alvarez-Jubete, 2009).

The studies also revealed the difference between unhusked and husked buckwheat used in GF bread formulations. Adding 10-30% unhusked buckwheat decreased the flavour and taste profile acceptance, while the same amount of husked buckwheat flour presented high acceptance in taste, high volume and better texture (Torbica, 2010; Yang, 2008).

It is essential to highlight the effect of proteins in buckwheat which might lead to an allergic reaction (Alvarez-Jubete, 2009; Heffler; 2011). Buckwheat is estimated to be the causative allergen in between 3-3.5% of all anaphylaxis in South Korea and Japan (Imamura, 2008). Reports also show emerging buckwheat allergy in Italy and France (Heffler, 2011; Beaudoin, 2007).

NON-GLUTEN PROTEINS AND HYDROCOLLOIDS

Protein supplements like milk, soy, lupine, egg and pea protein have been frequently used in GFB formulations and showed effective anti-stalling, structure-forming impact increased water absorption ability and viscoelastic properties of the dough (Sahagún, 2018; Marco, 2008). Due to the higher water retention effect, the addition of more water to the GFB dough is demanded. It should be noted that egg protein increases the elasticity of the crumb and helps in developing a finer cell texture (Sahagún, 2018).

The presence of pea and lupine preparations improved the sensory parameters, providing more acceptable colour and smell, while soy showed a decreased consumer's scores. The addition of protein hardened the bread and in

enthalpy of retrograded amylopectin, during bread storage (Horstmann, 2017 and Ziobro, 2016).

The colour and textural properties of bread crumb and loaves are highly affected by the proteins. Mostly, dairy proteins are effective in enhancing Maillard's reaction and colour even in small doses (Krupa-Kozak, 2013). GFB samples with soy protein showed significantly darker crumb and crust (Taghdir, 2017).

Despite their technological advantages, it is important to emphasize that milk, egg, soy, and lupine proteins are allergens. This increases the complexity of allergen handling during food production for people having a CD with joined milk, egg, soy, or lupine allergy.

The impact of different hydrocolloids on the characteristics of dough and bread quality is highly dependent on the raw materials, nature and quantity of the hydrocolloids (Mir, 2006). Therefore, their usage is also complex and not unified. Hydroxypropyl methylcellulose (HPMC), sodium carboxymethyl cellulose (NaCMC), guar gum or xanthan also might have a positive influence on the rheological properties, volume, crumb hardness, and/or texture increasing the water retention, stabilizing emulsions, foams, and suspensions (Nicolae, 2006; Hager, 2013; Nie, 2016).

The integration of oats and hydrocolloids has a tendency of boosting the bread volume. For instance, a mixture of xanthan gum, potato flour, and apple pectin resulted in a massive increase in bread volume (Lazaridou, 2007). However, it was noted that the increase in size leads to the softening of the whole bread. In this perspective, it is important to note that this type of hydrocolloid works perfectly with corn and soybean starch. Also, the introduction of HPMC and guar gum in corn starch resulted in increased elasticity of dough and the general softness of the bread. Therefore, the addition of non-gluten products needs to be done in measurable quantities for better results. Other types of starch like dextrin, cationic and amphoteric can also be used with hydrocolloids.

From nutrition perspective, hydrocolloids are beneficial. Cellulose, psyllium and guar gum enhances digestion and absorption. It prolongs the mouth to cecum transit time, delays gastric emptying, slows down the increase in postprandial glycaemia and provides benefits to the colonic function (Fratelli, 2018).

The positive effects of dietary fibres like β -glucan, inulin, oligofructose, apple fibre, and psyllium fibre are still known. They comprise the higher intakes of dietary fibre that

reduces the risk of developing several chronic diseases, including cardiovascular disease, type 2 diabetes, and some cancers, and are associated with lower body weights (Dahl, 2015). From the food technology perspective, they provide water binding, increased viscosity, and gel-forming capacities in bread formulations (Fratelli, 2018). The higher amount of psyllium fibre might have the laxative effect due to its bulking effect as it expands and forms a gel-like mass in the colon (Mishra, 2014).

CONCLUSION

Over the last decades, the general awareness and medical knowledge about CD, NCGS or WA have substantially developed. Although the usage of gluten-free ingredients and processing techniques are emerging rapidly, the nutritional properties, quality and sensory properties of gluten-free bread are still incomparable to the gluten-containing standards. To the best of our knowledge, there is no solution discovered yet which can replace the gluten completely. The combination of certain ingredients, additives and technologies are providing promising results, keeping the door open for further improvements but it is difficult to define the best formulation as there are a lot of positive results, but on different recipes, raw materials and final products. Therefore, the new GF formulations should also focus on the raw material price and testing with a large number of consumers.

Data availability

The data used to support the findings of this study are included within the article.

Disclosure of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Author contribution

Marcell Toth has contributed to the literature review, reference selection, and preparing manuscript. Gyula Vatai contributed in literature review, and journal selection.

Andras Koris has helped in literature review, reference selection, and manuscript review.

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